GEOLOGY OF VAN BUREN COUNTY.

BY

C. H. GORDON.

GEOLOGY OF VAN BUREN COUNTY.

BY CHARLES H. GORDON.

CONTENTS.

INTRODUCTION.

Van Buren county lies on the southern border of the state, and is the second county from the east. Between it and the Mississippi river lies Lee county, while Henry borders it on the northeast, Jefferson on the north, and Davis on the west. Scotland and Clarke counties of Missouri join it on the south.

The county is an approximate square and contains 484 square miles. It is among the number which were earliest settled and was already, to some extent, occupied when visited by Owen. Since his explorations, geological work has been carried on within its limits by both Worthen[1] and White[2] though no exhaustive report on the area has heretofore been published.

PHYSIOGRAPHY.

TOPOGRAPHY.

The county is divided into two triangular areas by the Des Moines, which cuts it diagonally from northwest to southeast. In its relief it approximates that of Lee county on the east, consisting of a broad, level plain affected by a general southeast drainage. From its position, the main drainage is accomplished by the Des Moines river and its tributaries. For several miles on either side of the stream, the plain has been dissected by numerous comparatively short trenches which meet the chief water course usually at high angles. This is especially true below Kilbourne where the streams have cut deep gashes into the indurated rocks. Above the point named, the coal measure beds descend gradually to the river level and here, owing to the softer character of the rocks, erosion has effected more extensive changes in the surface. This is seen in the more general denudation and levelling which the plateau has suffered, as well as in the lessening of the angles which mark the dendritic river systems. On the northeast, the streams setting back from the Des Moines and from the Skunk have not yet completely invaded the plateau which is here broad and flat and imperfectly drained. Joined with the general plain,

[1] Worthen: Geol. Iowa, I, 219-230. 1858.

[2] White: Sec. Ann. Rep. State Geologist, 112-117. 1868.

and constituting a part of it, are the narrow divides between the tributaries of the Des Moines. These project southward nearly to the river, their summits evidently representing the remnants of the original plain surface out of which they have been carved. So also southwest of the Des Moines the plateau feature is marked, though instead of a single broad, flat prairie, like that on the north side of the river, the plain surface is here represented by a series of parallel, broad-topped divides separating the southeastward flowing streams.

General Plateau. In the southwestern part of the county, the Chicago, Burlington & Kansas City railroad has occupied the strip between the Fox and Little Fox rivers nearly to the state line. At Milton the elevation is 800 feet above tide, while a few miles east of Cantril the summit of the divide is 785 feet. East of Mount Sterling the plateau level stands at 734 feet above sea level. On the north, the highest point is at Birmingham where the elevation is 758 feet. From this point, there is a gentle slope to the east as before. Birmingham and Mount Sterling lie very nearly on the same meridian and hence their elevations indicate a southward slope of the plateau surface of twenty-four feet, or about one and one-half feet per mile. The general relief therefore corresponds to that observed in Lee county; a broad, smooth plain tilted to the southeast.

The following are the known elevations:

ALTITUDES IN VAN BUREN COUNTY.

STATION.	Above low water at Keokuk.	Above sea level at station.	AUTHORITIES.
Birmingham	291	758	Ft. Madison & D. M. R. R.
Bentonsport	122	599	Geol. Rep. 1870, vol. II.
Bonaparte	98	575	Geol. Rep. 1870, vol. II.
Boyer's	119	596	C., B. & K. C. R. R.
Cantril	293	770	C., B. & K. C. R. R.
Douds	157	634	Geol. Rep. 1870, vol. II.
Farmington	91	568	Gannett's Dictionary.
			C., B. & K. C. R. R.
Keosauqua	187	664	Levelled.

ALTITUDES IN VAN BUREN COUNTY—*Continued.*

STATION.	Above low water at Keokuk.	Above sea level at station.	AUTHORITIES.
River level at Keosauqua		590	
Kilbourne	147	624	Geol. Rep. 1870, vol. II.
Longview	277	754	Ft. Madison & D. M. R. R.
McVeigh	276	753	Ft. Madison & D. M. R. R.
Mount Zion	247	724	Geol. Rep. 1870, vol. II.
Milton	323	800	C., B. & K. C. R. R.
Mount Sterling	168	635	C., B. & K. C. R. R.
Selma	170	647	Geol. Rep. 1870, vol. II.
Stockport	276	753	Ft. Madison & D. M. R. R.
Willets	121	598	C., B. & K. C. R. R.

DRAINAGE.

By far the larger part of the drainage is effected by the Des Moines and its tributaries. In addition, however, two minor drainage areas appear; one at the northeast, tributary to Cedar Creek, and the other toward the southwest dependent upon Fox river.

Des Moines. The Des Moines river flows nearly due southeast, and with one exception varies little from a direct course. This exception occurs in the center of the county where the river is abruptly deflected from its course to the southwestward, but soon returns, forming a deep U-shaped loop whose axis is at right angles to the general course of the stream. The length of the loop thus formed is about five miles, while across the neck the distance is not more than two miles. To make this short distance the river takes a roundabout course of fully twelve miles. The principal tributaries to the Des Moines are Indian, Bear, Chequest and Holcomb creeks on the south, and Reed, Coates and Lick creeks on the north.

Indian creek. This creek bisects the divide between the Des Moines and Fox rivers, flowing parallel with them from its source near the western line of the county to Willett station where it turns eastward. Except in the last four miles of its course, where it invades the Saint Louis limestone, the stream

flows over a thick bed of drift. In this portion the stream has comparatively wide bottoms with more or less abrupt, but rounded slopes.

Bear creek has a comparatively steep declivity. It takes its rise on the plateau level south of Keosauqua and, soon penetrating to the rock, is bordered in the lower half of its course by more or less prominent mural escarpments. It opens into the Des Moines at a high angle just south of Bentonsport.

Chequest creek rises in Davis county and flows approximately parallel to the general course of the Des Moines, into which it empties at Pittsburg. Throughout the greater part of

Figure 19. View looking down the Des Moines just below Bentonsport. Montrose cherts and Keokuk limestone form the escarpment at the left.

its course in Van Buren county, the stream flows over the limestone of the Saint Louis, in which it has cut a somewhat irregular channel with prominent rock escarpments.

Lick creek takes its rise in Jefferson county, flows southeastward and enters the Des Moines at Kilbourne. Throughout most of its course the channel is confined to the drift and coal measure formations, the latter of which, from lack of resisting materials, offers few exposures, and the region is marked by

rounded, hilly topography. Lick creek penetrates to the limestone, however, a short distance above Kilbourne, and from this point its course is marked by abrupt deflections and prominent rock escarpments.

Coates creek. Somewhat similar in character to Lick is Coates or Honey creek. Taking its rise in the upland plateau in numerous widely branching secondaries and flowing southward, it discharges into the Des Moines. It soon penetrates the drift and coal measure deposits, and its course thereafter is marked by more or less prominent rock acclivities carved in the Saint Louis limestone.

Reed creek is almost the counterpart of Coates, except that in its lower course it is more sinuous from deflections due to the peculiarities of the underlying rock structure.

Fox river. Next to the Des Moines, Fox river is the most important stream within the limits of the county. It takes its rise in Appanoose county, enters Van Buren about three miles north of Milton and leaves it a short distant below Mount Sterling. It flows approximately parallel to the Des Moines throughout its course and empties into the Mississippi a few miles below Alexandria, Missouri. In Van Buren county, it flows in a broad alluvial valley in which it meanders from side to side. Its channel is comparatively small and insufficient to carry the volume of water brought down during times of freshets, and overflowing, it renders a large part of the rich alluvial bottoms unfit for cultivation. Parallel with the Fox, and tributary to it, is the Little Fox in the extreme southwestern corner of the county.

STRATIGRAPHY.

General Relations of Strata.

The indurated rocks exposed in Van Buren county belong entirely to the Carboniferous formations. Exposures occur chiefly along the Des Moines and its tributaries. In the northeastern part of the county, Cedar creek and its branches also offer a limited area of outcrops.

Classification of Formations.

GROUP.	SYSTEM.	SERIES.	STAGE.	SUB-STAGE.
Cenozoic.	Pleistocene.			Teraces. Loess. Lower Till.
Paleozoic.	Carboniferous.	Upper Carboniferous. (Coal me'sures.)	Des Moines. (Lower Coal Measures.)	
		Mississippian Lower Carboniferous.	Saint Louis.	Compact and granular limestone. Brecciated limestone. Arenaceo-magnesian beds.
			*Keokuk.	Warsaw shales and limestones. Geode shales. Keokuk limestones.
			*Burlington.	Montrose cherts.

*The Keokuk and Burlington stages as used in this report are together the equivalent of the Augusta as used in the other reports of the Survey.

Between the Saint Louis and Des Moines formations is a marked unconformity which corresponds in time to the interval represented further south by the Kaskaskia, the uppermost member of the Lower Carboniferous series in the Mississippi valley.

DESCRIPTION OF TYPICAL SECTIONS.

BENTONSPORT SECTION.

		FEET.
7.	Concealed	
6.	Limestone, magnesian; weathers brown	10
5.	Sandstone, shaly, blue; weathering to brown	5
4.	Geode bed; concealed in part	35
3.	Shales, calcareous, and limestone with chert and geodes	15
2.	Limestones, dark bluish-grey with Keokuk fossils, quarry bed	15
1.	Limestones and cherts to river level	35 to 40

Number 1 is evidently the equivalent of the chert beds at the top of the Burlington which constitutes the river bed between Montrose and Keokuk. The above rocks are also well exposed on the opposite side of the river on Bear creek.

KILBOURNE SECTION.

		FEET.	INCHES.
13.	Fire clay, red and grey	1	6
12.	Shales, arenaceous and bituminous	6	
11.	Coal		6
10.	Fire clay, grey	2	
9.	Sandstone, friable, more or less ferruginous and shaly	3	
8.	Shales, green, grey, arenaceous	6	
7.	Limestones, brecciated; upper part in places evenly stratified granular limestone	18	
6.	Limestone, magnesian, coarse, brown, vesicular	15 to 25	
5.	Concealed	10	
4.	Clay, arenaceous; blue or greenish	2	
3.	Concealed	23	
2.	Shale, calcareous, and thin beds of limestone with chert and geodes	8	
1.	Limestone, coarse, bluish-grey, with Keokuk fossils	3+	
		108	

The geodes in number 2 are not well developed, but clearly indicate their relationship to the siliceous masses in these shales at Keokuk. A well put down on the farm of Mr. H. B. Edmunson yielded the following section as given by the driller, Mr. R. G. Merrill.

EDMUNSON WELL SECTION.

(Tp. 69 N., R. IX W., sec. 26, Se. qr., Ne. ¼.)

		FEET.
10.	Clay, yellow, no sand	90
9.	Clay, blue	21
8.	Sand, no water	¼
7.	Shale, dark blue	55
6.	Rotten stone, yellow, much like ochre	3
5.	Limestone, brownish	10
4.	Shales, alternating with limestone	41
3.	Limestone	41
2.	Rock, hard, dark colored with much mineral (?)	4
1.	Rock, very hard, could not penetrate it, probably Montrose cherts	
		270¼

The elevation at the top of the well is about 745 feet. The shales given at number 7 may represent an unusually argillaceous development of the brecciated division not unlike that sometimes seen elsewhere. In that case numbers 5, 6, and 7 would represent the Saint Louis; 3 and 4, Keokuk, and 1 and 2 the upper part of the Burlington. The figures here given indicate a northward dip of about 140 feet in the distance of a mile and a half, between this point and Bentonsport.

A well put down on the farm of Mr. C. Davis by Mr. Merrill furnished the following record:

DAVIS WELL SECTION.

(One-quarter of a mile west of middle of Tp 68 N., R. IX W., sec. 8)

		FEET.
16.	Clay, yellow, with some sand	35
15.	Clay, blue, joint	5
14.	Clay, yellow; in layers one and a half to three feet thick, alternating with two to six inch layers of sand and some water	16
13.	Clay, blue, very hard; with boulders	29
12.	Shale, dark brown to black	10
11.	Coal	½
10.	Clay, brown	6
9.	Clay, white, with fragments of limestone	1
8.	Limestone, white	15
7.	Limestone, bluish-grey, with some pyrite	70
6.	Shale, dark to light greenish shades	30
5.	Shale, very dark	25
4.	Limestone, cherty and arenaceous	3
3.	Limestone, grey sub-crystalline	15
2.	Limestone, darker colored, mottled pink, grey and black	23
1.	Rock, hard, brownish grey, cuts the drill	32
	Total	315

Elevation at top of well about 725 feet above tide. In this section the coal measures are represented by 9, 10, 11 and 12, the Saint Louis by 7 and 8, while the remainder is Keokuk except 1, which evidently represents the Montrose chert. This locality is nearly southwest of Bentonsport and the figures indicate a difference of about 170 feet in the elevation of the strata. The distance in direct line is about four miles, showing a southwestward dip of over forty feet per mile.

A well on the farm of Mr. C. Miller, about a mile and a half northeast of Keosauqua, gives the following:

MILLER WELL SECTION.

		FEET.
10.	Clay, gray	8
9.	Sand	32
8.	Gravel with water	2
7.	Coal	3
6.	Limestone, white	8
5.	Lime and sand	8
4.	Limestone, grey	30
3.	Sandstone, stained with iron oxide	3
2.	Sandstone, bluish grey	12
1.	Shale, blue	56
		162

This section corresponds very closely with the preceding in the thickness of the blue shale number 1. It evidently represents the Warsaw and Geode shale beds; doubtless in large part the latter.

The following section was obtained by combining sections from several localities on Indian creek opposite Farmington, no one of which gave a complete exposure of all the beds:

FARMINGTON SECTION.

		FEET.
10.	Clay, yellow, boulder	10
9.	Sandstone, incoherent, thin-bedded, brownish grey,	3
8.	Sandstone, incoherent, varying to sandy shale, ash colored "clod" below	7½
7.	Coal, impure	½
6.	Clay and sandstone, arenaceous	2
5.	Clay, residuary, containing fragments of limestone and chert, and considerable ochre	½
4.	Limestone, magnesian brown and finely vesicular	6
3.	Sandstone, blue and arenaceous shale	3
2.	Shale, blue with thin beds of sub-crystalline limestone. A bed of the limestone two feet thick in places, at the base	7 to 10
1.	Shales, calcareous. with geodes to bed of creek (base of section about five feet above river level)	2
		44½

Numbers 6 to 9 represent the Des Moines beds; 3 and 4 the Saint Louis, here nearly all removed by erosion before the deposition of the coal measure deposits, while the Warsaw, greatly

reduced in thickness, is represented by number 2, and the Geode shales by number 1. Farther up the creek the brecciated limestone of the Saint Louis stage comes in just below the coal measure deposits.

UMPHREY BROTHERS WELL SECTION AT PITTSBURG.*

(Tp. 69 N., R. 10 W., sec. 34, Nw. ¼.)

		FEET.
15.	Clay, yellow	10
14.	Sand	4
13.	Clay, yellow	5
12.	Sand	1
11.	Clay, yellow, growing harder below	4
10.	Gravel and sand firmly cemented with iron oxide	18
9.	Clay, dark, with limestone in upper part	38
8.	Shale, blue, with some limestone	30
7.	Clay, ochreous	1
6.	Clay, white	6
5.	Clay, red like umber	13
4.	Limestone, white (water)	15
3.	Limestone, grey	4
2.	Sandstone, fine, bluish grey	5
1.	Limestone, grey with pyrites (water)	37½
		191½

This well is situated on the hill south of Pittsburg, about seventy feet above the level of the river. At a point opposite the location of the well, the lower members of the Saint Louis limestone crop out in the river bank, while coal measure shales appear twenty-five to thirty feet above. The members of the section are identified with difficulty, and some doubt exists as to the reliability of the observations. The clay and shale below the gravel (No. 10) may represent the brecciated bed, or it may belong to the boulder clay of the drift, and hence indicate a filled channel. The record is inserted without attempting a correlation.

Geological Formations.

BURLINGTON.

The lowest rocks exposed within the limits of the county belong to the Burlington, the second member of the Mississippian or Lower Carboniferous series. Their exposure is confined

*Record furnished by Mr. Merrill.

to the channel of the Des Moines between Bentonsport and Bonaparte. They emerge from the bed of the river about a mile and a half above Bentonsport. At the latter place they reach a height of about forty feet above the river level, decline very gradually to Bonaparte, and then shortly disappear below the level of the stream. The only part of these beds to be seen is the chert formation at the top, which has been called the Montrose chert. They consist of beds of chert with occasional thin beds of limestone, or calcareous shale. A few feet of limestone appears at the river level on the south side, about half way between the places named, which may represent the uppermost part of the upper Burlington limestone. These beds have been penetrated by a shaft at Bonaparte and are there called the "Bonaparte Marble." The cherts break down quickly on exposure and hence offer comparatively few sections for study. Below Bentonsport, however, good exposures occur along the railroad for a mile or more.

KEOKUK.

The rocks of this member have their greatest exposure along the channel of the Des Moines from the mouth of Rock creek to the eastern limit of the county. A limited exposure also occurs at the mouth of Lick creek. They owe their exposure entirely to the erosion of the river and its tributaries, and their areal development is confined to a narrow belt along the stream.

In the vicinity of the confluence of the Des Moines with the Mississippi, this formation presents three well marked divisions. From below upwards these are the Keokuk limestone, the Geode shales, and the Warsaw shales and limestone. In Van Buren county the two lower divisions have essentially the same development as in Lee county, but the Warsaw formation is greatly reduced in thickness and evidently wedges out before reaching the northern limit of the county.

Keokuk Limestone. The general section given above represents the typical development of this bed. It makes its first appearance in the extreme southeastern part of the county on a small branch on the south side of the river. About six or

eight feet are exposed and quarried to a limited extent. The next appearance is at the mouth of Reed creek, where about ten feet of bluish grey limestone, coarse, sub-crystalline and mostly thin bedded are exposed. As the strata rise toward the west, lower beds come into view, and are seen well up in

Figure 20. Escarpment of Keokuk limestone below Bonaparte.

the bluff below Bonaparte, with nearly thirty feet of the Burlington chert beds below. The limestone has been quarried at several places here, but it contains large quantities of chert. Much of the rock is also shaly and the bedding of the better quality of rock is quite variable. At Bentonsport at one time, quarrying was carried on quite extensively. The principal quarry bed is about five or eight feet above the base of the division and perhaps represents the same ledge as that quarried at Keokuk and there termed the "white ledge." The upper layers at the quarry are thinner. The horizon between the thicker and thinner beds is marked by a series of undulations of one of the beds remarkable for their regularity. The vertical interval of the undulations does not exceed ten inches,

while the horizontal interval does not vary much from fifteen feet throughout the whole extent of the quarry. On the opposite side of the river the rocks are well exposed for some distance up Bear creek, and show essentially the same characters as elsewhere in southeastern Iowa.

Geode Shales. Above the Keokuk limestone lies a bed of bluish grey calcareous shale containing hollow siliceous masses termed geodes. The geodes vary from one inch to two feet in diameter, but are usually from six to ten inches. They are studded on the interior with crystals of calcite or quartz, or lined with chalcedony. In some places these bodies are very numerous in the beds of the streams which dissect the shales in which they occur. They are quite abundant in the vicinity of Farmington where they have been exposed by Indian creek and other small tributaries. They also occur on Bear creek and other places in the vicinity of Bentonsport. On Rock and Copperas creeks where the upper part only of the shales is exposed, the siliceous masses are irregular in shape and instead of being hollow, consist of masses of red and white, partially crystallized calcite. Their crushed form suggests that the geodic structure was here interfered with by agencies not acting elsewhere, and as there are indications of an unconformity in this locality not far above this horizon. It may be that the shales were subject to shore influences which prevented the complete development of the geodic form.

The greatest thickness of these shales known in Lee county is forty feet. At Bentonsport as shown by the section there is a covered slope of thirty-five feet with fifteen feet of the geode shales below. The concealed portion is probably in large part of the same formation; the remainder being the Warsaw. The Davis and Miller well sections, given above, agree in showing about fifty-five feet of shale at this horizon, of which about ten or fifteen feet doubtless represent the Warsaw, so that the thickness of the geode shales in Van Buren county does not vary much from forty to forty-five feet.

Warsaw Shales and Limestones. Below the mouth of the Des Moines river at Warsaw, Illinois, the upper beds of the Keokuk sub-stage have a development of about forty feet.

They thin rapidly northward however, and in Van Buren county along the Des Moines they are represented by only ten to fifteen feet of blue shales, including bands of fossiliferous limestone. Though greatly diminished in thickness they retain essentially the same characters as at the typical locality. At the mouth of Indian creek this formation is represented by seven to ten feet of blue shale with thin layers of blue sub-crystalline limerock. One of these beds, two feet thick, lies at the base of the division.

On Rock creek, at an old quarry (Tp. 69 N., R. IX W., sec. 16, Sw. qr.) this formation is represented by eight to ten feet of blue shales with limestones interbedded as at Farmington. The limestones here are composed in large part of the fragmentary remains of fossils many of which are identical with those of the same horizon seen at Keokuk. East of this locality, on a branch of Copperas creek, a thin ledge of limestone overlain by a few feet only of arenaceous blue shale, intervenes between the Geode bed and the magnesian limestone of the Saint Louis. The shales grade into a hard, very fine grained blue sandstone which is said to have once been used locally for scythe stones. It is thin bedded and includes broken fragments of chert and shells. A similar deposit occurs on Rock creek above the Warsaw formation. As there are commonly no means for discriminating between the shales of the Warsaw and Geode beds in well sections, there is some doubt as to what part of the fifty-five feet of shales shown in the Edmondson and Davis records belong to the Warsaw. The formation evidently does not extend much north of this area, and doubtless it wedges out entirely before reaching the northern boundary of the county.

SAINT LOUIS.

The Saint Louis limestone constitutes the uppermost division of the Mississippian or Lower Carboniferous series in Iowa, and has the greatest superficial extent of any of these members in Van Buren county. It is generally overlain by the rocks of the Des Moines stage of the Upper Carboniferous (coal measure) series, and its exposure is due chiefly to the removal of these and the overlying drift deposits by the extensive erosion of the Des

Moines river and its tributaries. The maximum thickness in Van Buren county probably does not exceed ninety feet.

In lithologial characters the rocks composing the formation show great variation. In general they present a three-fold division consisting of (1) brown, arenaceous and magnesian limestone, (2) brecciated limestone, and (3) grey, compact and granular limestone.

Arenaceo-magnesian Beds. The first of these is exposed at many places along the Des Moines and is especially well developed in the vicinity of Kilbourn and in the bluffs below Keosauqua. It consists of fine-grained or vesicular magnesian limestone in

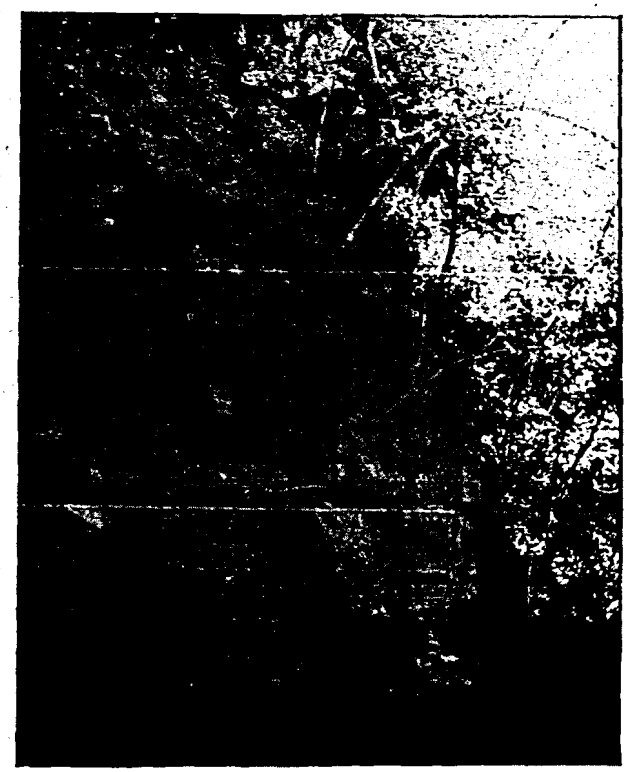


Figure 21. Old quarry at the mouth of Rock Creek. Arenaceo-magnesian beds overlain by brecciated limestone.

rather heavy ledges, which grade horizontally into a more or less clearly marked arenaceous rock characterized in places as a sandstone. A large percentage of the rock, however, is made

up of calcareous matter, and hence it is more properly designated as an arenaceous limestone. It is well developed on Price and Bear creeks where it furnishes a very good quality of stone for building purposes, and has been quarried quite extensively for plates and sills. This bed represents that quarried at Belfast and Keokuk. It constitutes the upper member of the Warsaw as originally defined. The arenaceous character is confined generally to the lower part of the beds, but on Bear creek as well as elsewhere, sand forms the larger part of the formation, The magnesian limestone constitutes the most generally recognized phase of the division in the county. When first removed from the bed, the rock is of a blue or drab color, but it soon changes to a rusty brown by the oxidation of the iron which it contains. In general, therefore, the exposures of both the arenaceous and magnesian ledges are characterized by a rusty brown color. The magnesian rock occurs in thick, gently undulating beds, and is distinguished by a more or less concretionary structure by reason of which it was at first termed the Lower Concretionary limestone by Owen. In places these beds are interrupted by the brecciated phase which in these instances is in direct continuity with that of the overlying bed. The thickness of the arenaceo-magnesian beds varies from ten to twenty-five feet.

Brecciated Limestone is a widely recognized phase of the formation in Iowa. The bed is made up generally of compact and granular, grey limestones, in sharp angular fragments of various sizes cemented together by similar calcareous material. In many cases the fragments show more or less rounding as though they had been subjected to the wearing action of water. In the thicker portions of the beds, the spaces between the fragments are filled with greenish clay which sometimes contains fossils. There is usually a coarse stratification observable. In some cases the disturbing agencies have but very slightly affected the orderly arrangement of the formation. Elsewhere, however, the brecciated character is marked, as for instance near the mouth of Reed creek, where it affects the whole of an exposure seventy-five to eighty feet in height. The lower portion represents the arenaceo-magnesian bed and

is composed of large fragments of this limestone with clay filling the interstices, while the upper part is made up of the compact and granular limestone more completely cemented. In a few instances the brecciated character has been observed to fail altogether and the lower division is succeeded by compact grey limestone similar to that of which the brecciated bed in its general extent is composed, and which is indistinguishable from the limestone constituting the upper division. In the vicinity of Keosauqua, the upper portion of the bed contains more or less arenaceous material. This is well marked on the south side of the Des Moines above the town, where a brown sandstone ten to twenty feet thick replaces nearly the whole brecciated division and is overlain by the limestone described farther on. Two or three miles below, the sandstone varies from five to twenty-five feet in thickness and rests upon the brecciated bed, while it is overlain by the compact limestones as shown in the bluffs opposite Keosauqua. This sandstone was regarded by White* as the equivalent of that above the Warsaw shales at Keokuk and the town of Warsaw.

The sandstone at Keosauqua is decidedly calcareous in places, and sometimes includes irregular ledges and fragments of limestone. It is there seen to be closely related to the brecciated division and evidently constitutes a phasal development of that formation. Outside of the ox-bow area it has been recognized at two localities only; one on Coates creek and the other in Lee county on a branch of East Sugar creek. The thickness of the brecciated division varies from nothing to seventy-five feet. In general however, it may be said to be from ten to twenty feet thick.

Compact and Granular Limestone. Overlying the brecciated limestone in places, and the Keosauqua sandstone where that formation occurs, is a compact, fine-grained, grey limestone characterized by having a conchoidal fracture, concretions, and a considerable number of fossils, the most prominent of which are *Spifer littoni* Swallow, and *Rhynchonella ottumwa* White. In some places the compact limestone is replaced by a thin bedded limerock with a marked granular structure often cross-bedded

*Geology of Iowa, vol. I, p. 218. 1870.

and showing well developed ripple marks upon the surface. The limestone of this upper division is well developed along Indian creek where the compact variety is quarried quite extensively. It is also quarried at Keosauqua on both sides of the river. In some localities it is absent, allowing the brecciated beds to constitute the surface rock. This is prevailingly the case in Lee county. While in general its absence may be attributed to erosion, it seems probable that it may often be accounted for by non-deposition, and toward the north doubtless this is generally the case. The thickness of the bed does not exceed fifteen feet.

DESCRIPTION OF SECTIONS.

Opposite Farmington, just above the railroad bridge, twenty feet of arenaceous shales, with some coal, appear about thirty-five feet above the level of the river. A few hundred yards above this the bluff shows about thirty feet of limestone more or less brecciated and disturbed. The limestone replaces the sandstone and shales, showing that the latter were deposited in a depression in the surface of the limestone. The accompanying figure illustrates these relations.

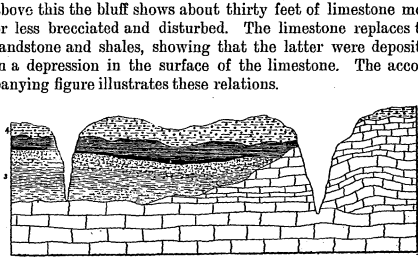


Figure 22. Section at Farminton showing coal measure deposits resting in depression in Saint Louis limestone. 1. Arenaceo-Magnesian beds. 2. Brecciated limestone. 3. Coal measure, sandstone and shales with seams of coal. 4. Surface clay.

On Indian creek a short distance above its mouth, the arenaceo-magnesian member is represented by three feet of sandstone, overlain by a like thickness of magnesian limestone, and resting on this are coal measure deposits. A short distance above this locality, the brecciated limestone appears, intervening between the magnesian limestone and a sandstone which

may represent the basal member of the coal measures, though it may be the equivalent of the Keosauqua sandstone. About a mile west of Boyer station, the compact, white limestone has been quarried quite extensively, fifteen feet of the limestone being exposed above the creek bed. The lower three feet is somewhat thinly bedded and granular, the remainder is a light grey compact limestone with some nodular chert. The rock is very hard, breaks with conchoidal fractures, and weathers white. In the clay seams separating the beds a number of fossils are found, the most common being *Spirifer littoni* Swallow and *Rhynchonella ottumwa* White.

A quarter of a mile east of this, at an old lime kiln, a rock evidently representing the lower part of the above is cross-bedded and granular in structure. On Reed creek, three-fourths of a mile above its mouth, the eastern bluff shows a rock face seventy-five feet high, all of which is more or less brecciated. The lower two-thirds is composed of large, irregular masses of brownish limestone, with green clay filling the interstices, and the whole very irregularly and coarsely stratified. The upper part of the escarpment is composed of white limestone breccia and is more regularly stratified. The limestone in the lower part has evidently been derived from the underlying magnesian limestone, while the upper is as manifestly related to the white limestone. Between this point and the mouth of the creek, on the west side, the lower portion of this section is replaced by the arenaceo-magnesian beds as follows:

		FEET.
3.	Limestone, brecciated	5
2.	Limestone, magnesian, blue; weathering brown; lower stratum disturbed along the middle where it is made up largely of clay with included siliceous fragments, more or less water worn	20
1.	Sandstone, blue, calcereous	4
		29

In the north bluff of the Des Moines, above the mouth of the same creek, the magnesian limestone has been quarried. It is here overlain by eight to ten feet of brecciated limestone. Near by, the latter is seen to grade upward into a cross-bedded

granular variety. On Bear creek, the blue sandstone has been extensively quarried (Tp. 68 N., R. IX W., sec. 11, Nw. qr.). It is here nearly twenty feet thick and is composed of massive sand beds separated by a considerable thickness of arenaceous shales. Farther up the creek it is more regularly bedded and grades into blue and brown magnesian limestone. At the mouth of Rock creek the following section is shown:

ROCK CREEK SECTION A.

		FEET.
6.	Concealed	5
5.	Limestone, compact, grey; breaking with conchoidal fracture; contains abundant *Spirifer littoni* Swallow and *Rhynchonella ottumwa*, White	6
4.	Sandstone, brown quartzose	4
3.	Limestone, brecciated, well cemented	20
2.	Limestone, hard, blue; weathering brown; heavily bedded and concretionary	14
1.	Concealed to river level	35
		84

Number 2 has been quite extensively quarried here for the old river improvements. About one-half mile north-west another old quarry shows some of the underlying beds.

ROCK CREEK SECTION B.

		FEET.
4.	Concealed	5
3.	Limestone, magnesian, concretionary, in heavy ledges; lower bed irregular	23
2.	Shale, sandy, blue and ash colored; inclosing fragments of chert and buff colored limestone more or less confusedly interstratified; lower portion partially decomposed limestone	6
1.	Shale, blue; interbedded with coarse sub-crystalline limestone, composed in large part of fossil fragments	8 to 10
		44

The lower bed here belongs to the Warsaw and the presence of concretions in the bed of the creek indicates that the Geode shales lie not far below.

About one mile southwest of the locality of the first section, the sandstone (No. 4), has a local development of nearly twenty-five feet. Two and one-half miles below Keosauqua on the

south side of the river, a high escarpment shows a similar section. Here the lower beds are arenaceous, grading horizontally into more or less pure magnesian limestone. Opposite Keosauqua the same sandstone is very irregularly stratified. An exposure at the south end of the bridge shows imperfectly consolidated calcareous sandstone including some limestone. In the ravine south of the bridge is the Manning quarry which has been opened in the grey, compact limestone overlying the sandstone. These beds have a thickness here of about twelve feet. The thin clay seams separating the beds are filled with fossils. These beds are equivalent to those quarried on Indian creek. They are also quarried on the north side of the river below the city. One-half mile southwest, on Thatcher creek, the sandstone is seen to include irregular beds of siliceous limestone. Another exposure in this vicinity shows a brecciation of the beds, evidently of later date, as it seemingly occupies a channel-like depression cutting through the sandstone to the limestone below. Above the mouth of the creek, the sandstone is fifteen to twenty feet thick and constitutes a rather bold escarpment along the river for a distance of more than two miles. It is overlain by the grey, compact limestone noted in the quarry at Keosauqua.

The Saint Louis limestone is well exposed all along Chequest creek from the middle of Chequest township to Pittsburg. The lower portion of the magnesian limestone grades locally into sandstone. This sandstone is taken out at the Price quarry (Tp. 69 N., R. X W., sec. 20, Sw. qr.). The rock here consists of a rather bluish gritstone which becomes brown and hard on exposure, thus constituting a good material for heavy masonry. The beds are cross-stratified and in places are too irregular for quarrying. Following down the branch they are seen to grade more or less into the magnesian beds along Chequest creek.

CHEQUEST SECTION.

(At mouth of Price creek.)

		FEET.
3.	Limestone, grey, compact; upper part somewhat granular, several ledges furnishing good quarry rock; a layer of dark colored, compact limestone near the base known as Chequest marble	20
2.	Limestone, blue or brown, arenaceous; the equivalent of the sandstone at the Price quarry,	8 to 10
1.	Limestone, graded downward into blue arenaceous shales	2

In this section the brecciated bed is absent. The brecciated character, however, is well developed at various other localities along Chequest creek. Its place here is evidently represented by the lower part of number 3.

About one and one-half miles southeast of Kilbourne the bluff gives the following:

		FEET.
7.	Limestone, white or grey, granular, replaced horizontally by a thickening of number 6	10
6.	Limestone, brecciated	1 to 10
5.	Limestone, magnesian, buff and brown in three or four heavy ledges	10
4.	Limestone, magnesian, fine-grained, soft; breaks down readily on exposure	2
3.	Limestone, magnesian, very siliceous and concretionary; lower ledge disturbed and replaced in part by clay containing siliceous fragments apparently water-worn	3
2.	Shale, blue, arenaceous; with more or less calcareous and magnesian material; imperfectly bedded	6
1.	Concealed to river level	20

On Lick creek both the magnesian and the brecciated limestones are well developed; the former showing marked indications of cross-bedding. These beds are also well exposed on Coates or Honey creek.

DES MOINES STAGE OR LOWER COAL MEASURES.

These deposits cover the larger part of the county, though over considerable areas occurring only as a thin veneer filling the irregularities in the surface of the underlying limestones. The depressions sometimes take the form of trough-like basins

extending north and south and are evidently due to conditions of antecedent drainage. One of the basins is in the southeastern part of the county, apparently trending northeast and southwest, and dissected at Farmington by the Des Moines river. Coal has been mined to a considerable extent on the north side of the stream. Its presence on the south side is shown by outcroppings along Indian creek and by mining which has been carried on at the Height bank (Tp. 67 N., R. VIII W., sec. 3, Se. qr). An attempt was made to mine the coal in the bluff opposite Farmington but it was unsuccessful. On the north side considerable coal has been mined (Tp. 68 N., R. VIII W., sec 36, Nw. qr.) but these workings are not now operated. A mine in the southeast quarter of section twenty-six of the same township and range is still being run on a small scale. The coal here occurs in small detached areas varying from ten to twenty-five acres in extent. It fills basin-like depressions in the underlying limestones. Four of these are known on the north side at Farmington and are found to be approximately parallel with the course of the river.

Each coal bed is usually underlain by fire clay and sandstone, but this sandstone occasionally fails, and then it rests directly upon the limestone. In some cases the fire clay and sandstone occur at the center, but wedge out at the edge of the basin. The following represents the succession as shown by drill records in a coal area.

FARMINGTON COAL SECTION.

		FEET.	INCHES.
18.	Clay, reddish, yellow	60	
17.	Clay, blue	20	
16.	Shale, black	6 to 10	
15.	Sandstone, coarse grey	1	8
14.	Coal	1	2
13.	Sandstone		8
12.	Coal	1	
11.	Fire clay and shale, bluish	5	
10.	Shale, blue	15	
9.	Shale	2	6
8.	Coal		6
7.	Sandstone		3
6.	Coal		1
5.	Sandstone	1	8

		FEET.	INCHES.
4.	Coal	4 to 5	
3.	Fire clay	0 to 3	
2.	Sandstone	0 to 6	
1.	Limestone (Saint Louis)	1	
		135	6

Number 4 furnishes the only workable bed of coal of this area. As it is not continuous, however, no correlation can be made with other districts.

North of Bonaparte another north and south depression gives rise to several basins of coal along Coates creek. These have not been fully developed and some of them may prove of sufficient extent for profitable working.

Northwest of Bentonsport, the coal measures rest upon the declining surface of the lower beds. On the Shepherd farm coal is obtained by stripping near the road opposite the farm residence. The Edmunson well is situated about a mile and a quarter southeast of this on much higher ground, but shows no coal measures, so that the coal bed probably belongs to a small outlier.

Coal occurs north of this and is said to have been taken out for local use (Tp. 69 N., R. XIX W., sec. 23, Ne. qr). A depression in the limestone on Rock creek, three-fourths of a mile above its mouth, is filled with the bituminous shales of the coal measures. There are indications of coal in a ravine about half a mile west of this, and again farther up the stream. The Miller well section shows three feet of coal at a depth of forty-two feet from the surface. These occurrences evidently all belong to the same depression extending from the northeast toward the southwest.

On the south side of the river at Keosauqua, coal has been mined in the bluff below the bridge, and also along a ravine near by opening into the main valley. On Ely creek coal-bearing shales appear considerably below the level of the uplands.

Southeast of Keosauqua the coal measures crop out at several places. The Davis well record shows sixteen feet of shales including a three inch seam of coal, underlain by one foot of clay. An exposure about two miles east of this on Bear creek

(sec. 10), exhibits clays and shales with two thin seams of coal resting upon the Saint Louis limestone. About a mile north of the latter place considerable coal has been mined on the Boyer farm (Tp. 68 N., R. IX W., sec. 3).

In the northwestern part of the county the coal measure rocks have a much greater development, and include workable seams of coal at several localities. Several mines are operated at Douds station at a horizon considerably above that of the coal in the eastern part of the county. The following section was made at the Findley mine about one mile northeast of the station near Business Corners.

BUSINESS CORNERS SECTION.

		FEET.	INCHES.
12.	Concealed	20	
11.	Shale, blue, argillaceous	10	
10.	Coal		6
9.	Shale, arenaceous; filled with plant remains		10
8.	Coal		6
7.	Shale, becoming more argillaceous below	3	
6.	Coal		6
5.	Sandstone, filled with plant remains	1	
4.	Fire clay	1 to 2	
3.	Shale, black, fissile above, more compact below filled with ironstone concretions; the basal portion contains lenticular masses of black calcareous rock	4 to 5	
2.	Coal, sometimes partially cut out by the nodular masses above	3 to 4	
1.	Fire clay	2	
		49	4

In sinking the air shaft for the Carson mine not far from where the above section was made no coal was found. A boring was then put down to the limestone, a distance of sixty feet, all of which was found to be composed of clays and shales.

About a mile east of the station, in a small ravine, an eighteen inch seam of coal is seen above eight to ten feet of light colored shales and sandstone which in turn rest upon the Saint Louis brecciated limestone. This evidently occupies the same horizon as the beds worked in the eastern part of the county. The following is a section at the Ratcliff shaft. (Tp. 70 N., R. XI W., sec. 23, Nw. qr.)

RATCLIFF SHAFT SECTION.

		FEET.	INCHES.
13.	Clay	10 to 11	
12.	Shale, black, bituminous	11	
11.	Coal		6
10.	Fire clay	2	
9.	Shale	3 to 4	
8.	Limerock, black	1	
7.	Coal	1	6
6.	Fire clay	2	
5.	Shale, grey with limestone masses	4 to 6	
4.	Coal	3 to 4	6
3.	Fire clay	4	
2.	Concealed	8	
1.	Shale, blue; in well which starts about twelve feet below coal	22	

The coal on the Hinkle land (Tp. 70 N., R. III W., sec. 10, Sw. qr.), evidently occupies about the same horizon as the Doud coal. In the northeastern quarter of the same section a three to four foot bed of coal occurs on the farm of A. Overturff, not far below the plain level.

OVERTURFF SECTION.

		FEET.	INCHES.
12.	Shale, black	8	
11.	Coal	3	
10.	Clay seams		2
9.	Coal		8
8.	Fire clay	4	
7.	Concealed	30	
6.	Shale, black bituminous	8	
5.	Limerock, hard black, variable in thickness		2 to 10
4.	Shale, black fissile	2	
3.	Shale, black, argillaceous	2	
2.	Coal	1	6
1.	Fire clay	1	

The branch on which this exposure occurs is tributary to that intersecting the Hinkle area. In the absence of any indication of southward dip therefore, it seems safe to assume that the coal at the Overturff place represents a higher horizon than any yet considered.

While the coal measure rocks are known to occur on the south side of the river, they have, as yet, furnished very little workable coal. Near Selma, however, a bed has been worked for many years (Tp. 70 N., R. XI W., sec. 17, Sw. qr.). Recently on the Leifer land a test for coal has been made below that now worked, the section showing:

LEIFER SECTION.

		FEET.
7.	Coal (operated)	3
6.	Fire clay	4 to 6
5.	Shale, dark	4 to 6
4.	Shale, black, hard	40
3.	Shale, blue, hard	23
2.	Shale, white, gritty	1
1.	Limestone, hard, could not penetrate with drill	

The drilling began in number 4; number 1 is evidently the Saint Louis limestone.

In boring for coal at Birmingham the following record was obtained, the location being at the depot of the Fort Madison & Des Moines railway; elevation 758 feet above tide.

		FEET.	INCHES.
14.	Soil, black	2	
13.	Clay, yellow	*	
12.	Sand, fine, white		4
11.	Sandstone, grey	13	8
10.	Coal	1	2
9.	Shale, black	4	10
8.	Shale, red, sandy	10	
7.	Shale, black	4	
6.	Coal, impure	1	
5.	Shale, grey	1	2
4.	Limerock, black, bituminous		10
3.	Coal, impure	5	6
2.	Shale	10	
1.	Limestone, white	12	
		106	6

The seams encountered were not regarded as workable here. The Smith drift has recently been opened. The location of the mine is about eighty feet below the Birmingham depot. The

*Thickness of yellow clay doubtful. Original record gave 4 feet; a manifest error.

erosion of the streams has exposed coal measure strata at numerous places between Birmingham and Mount Zion. Outcrops in this region show a considerable development of sandstone, probably the equivalent of members of the Birmingham section. On a branch of Lick creek (Tp. 70 N., R. IX W., sec. 30.) near the school house the following rocks are exposed:

SCHOOL HOUSE SECTION.

		FEET.
5.	Sandstone, soft, micaceous, shaly; cross-bedded, becoming more or less massive in places.....	10
4.	Sandstone, ferruginous, nodular, disturbed bed; pieces of bituminous shale, coal, etc.....	1
3.	Coal, impure.....	1
2.	Fire clay .....3 to	4
1.	Concealed to bed of creek	8
		24

The coal here is about 110 feet below the Birmingham depot. In a branch on the Hartman farm in the southern half of section 32, (same range and township) is a section which belongs to a horizon immediately below the preceding:

HARTMAN SECTION.

		FEET.
6.	Sandstone, brown, shaly.....	3½
5.	Shale, sandy, grey, fissile, filled with iron concretions.....	4
4.	Iron ore, nodular band.....2 to	4
3.	Shale, blue, argillaceous; becoming black below; contains lenticular masses of black limerock above.....	6
2.	Coal, irregular in thickness (average).....	1
1.	Fire clay.....	2
		30½

The iron ore is closely associated with the limerock and is probably a replacement of the latter. The sandstone thins toward the west to a single ledge but thickens rapidly toward the southeast and is ten to fifteen feet thick a quarter of a mile away. If the sandstone here represents that seen in the school house section, which would seem to be the case, it indicates a northward dip to the beds of about seventy-five feet in a distance of a mile and a half. This dip is clearly indicated by the appearance of the beds where exposed.

On Rock creek about a mile east of Mount Zion a good exposure occurs on the Baker farm (Tp. 69 N., R. IX W., sec. 9, Sw. qr).

BAKER SECTION.

		FEET.	INCHES.
9.	Clay, alluvial	5	
8.	Coal, partially disintegrated		8
7.	Fire clay	3	6
6.	Shale, black, bituminous	10	
5.	Limerock, nearly black, bituminous; in a single ledge varying in thickness from..2 to	10	
4.	Shale, bituminous, with some coal.....1 to	6	
3.	Fire clay	3	
2.	Coal		3 to 8
1.	Shale, drab colored	1	

Shales and sandstones with indications of thin seams of coal occur at a higher level in the hillside to the east. Northeast of Birmingham a branch leading into Cedar creek has cut through the full thickness of the coal measure deposits. Several coal seams are exposed but none are of workable thickness. The section very closely approximates that of the drill record at the depot.

The coal measures become thin eastward and are cut through in the northeastern part of the county by Cedar creek and its tributaries. They include some workable beds of coal which are referred to elsewhere.

Several well records in the northeastern part of Harrisburg township show no evidence of coal-bearing strata. In the southwestern part of the county the indurated strata are effectually concealed by a heavy covering of drift which the deepest wells yet made have failed to penetrate.

EXPLANATION OF PLATE.

PLATE VI.

Figure 1 represents a profile section from Farmington to Selma along the Des Moines river (*A–B* geological map). In this, number 1 is the Burlington, 2 the Keokuk, 3 the Saint Louis, 4 the Des Moines (coal measure), and 5 the drift.

Figure 2 is a section from Birmingham to Cantril through Keosaqua (*C–D* geological map). The numbers in this section refer

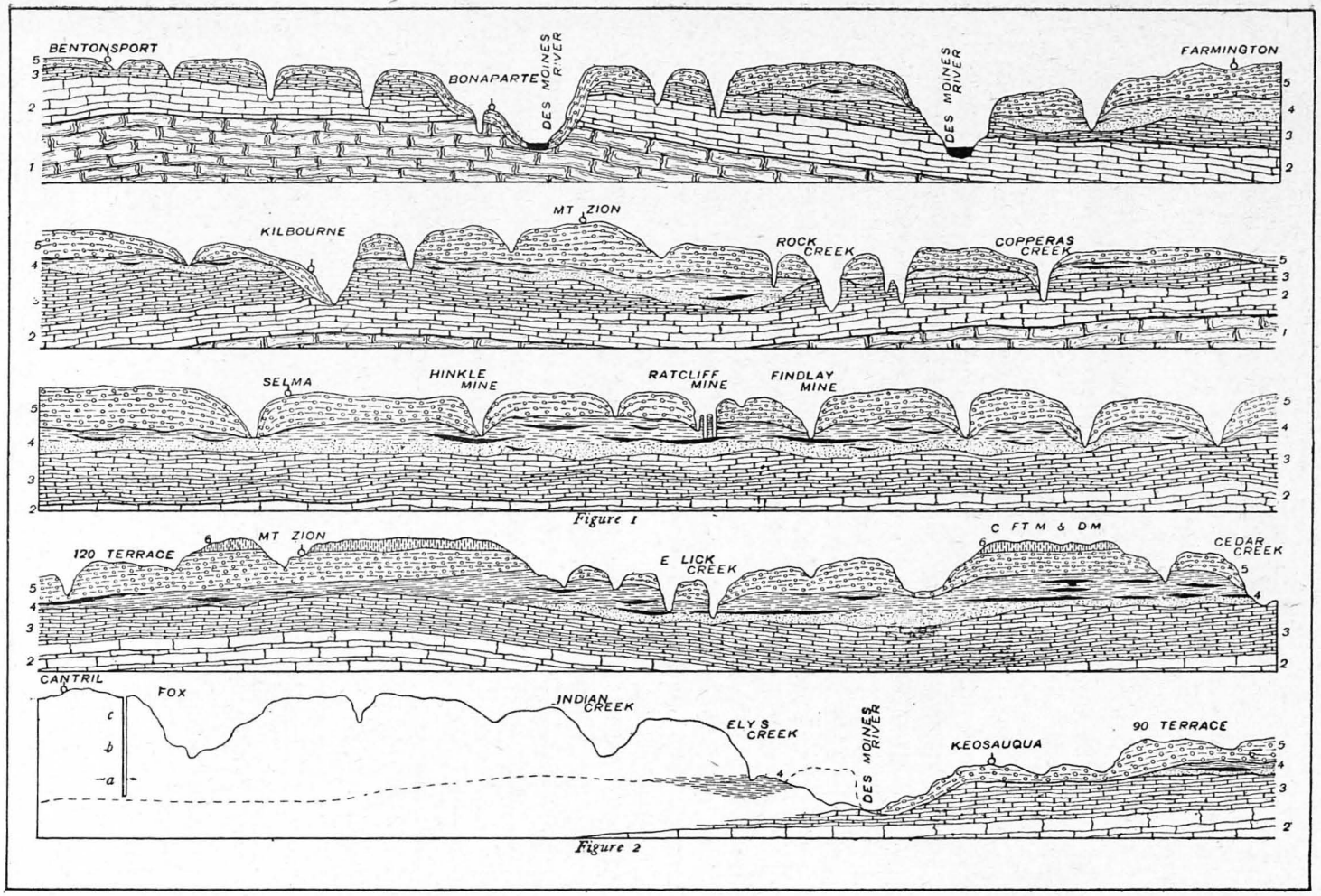
to the same formations as in figure 1; in addition, number 6 refers to the loess. In the well at Cantril *a* represents sand and gravel; *b*, blue clay; *c*, yellow clay.

PLEISTOCENE.

The Pleistocene deposits comprise the incoherent materials consisting of clays, sands, gravels and boulders which rest upon the indurated rocks. They originally covered the whole surface, building it up to a nearly uniform level, but they have since suffered much from erosion. Of later age are the alluvial deposits occurring along the valleys. These deposits may be classified as glacial, drift-loess and alluvium.

GLACIAL DEPOSITS.

The glacial deposits consist of two well marked divisions of boulder clays, each including more or less sand and gravel, a lower blue clay and an overlying yellow clay. No well defined boundary separates the two phases. They appear to grade gradually into each other, though the transition usually takes place within the space of a few feet. The opportunities for observations as to their relations, however, are few owing to concealment. At one point in the neighboring county of Lee, the blue clay was seen to terminate abruptly while the overlying deposit consisted of sand more or less cemented by iron oxide. As yet no satisfactory basis has been found for the separation of the two deposits, if indeed they do not belong to the same general formation. The most obvious distinction between the two is their color, and this is so patent as to be remarked by every well digger. Whether the characteristics of the yellow clay have a genetic significance or are due chiefly to oxidation and leaching is still an open question. The great thickness of this portion of the drift in places might be held to favor its separation from the blue clay. provided it is found to be supported by juncture phenomena, In the absence of such evidence however, it may be adduced as an indication of the vast period of time during which the deposits have been exposed to oxidizing agencies. The rate at which oxidation takes place downward, and the time which has



GEOLOGICAL CROSS-SECTIONS IN VAN BUREN COUNTY.

Scale { Vert. 200 feet. / Hor 1 mile.

elapsed since the withdrawal of the ice from this region are as yet wholly matters of conjecture. The separation of the clays is here made only as a matter of convenience in description, and is not intended in any sense as an expression of opinion as to their genetic relationship.

Blue Clay. The lower clay is dark blue, compact and hard. It is filled with crystalline pebbles and small boulders frequently worn and striated. Among these greenstone and quartzites are common. Occasionally larger boulders of quartz-porphyry and granite may be observed. These are most abundant along the valley of the Des Moines, having been uncovered by the river in the process of erosion. No distinct boulder trains or morainic deposits have been observed in the county. The blue clays include lenticular beds of sand or gravel which are usually relied upon for the water supply in the wells of the region. The thickness of the deposit in the northern and eastern part of the county, as shown by well records, varies from nothing to about fifty feet. It is much thicker in the southeastern part, as indicated in the Holland well north of Milton, and also in the Manning well near Cantril. In the bluffs of Fox river (Tp. 68 N., R. X W., sec. 31, Ne. qr.), there is a thickness of about seventy-five feet of blue clay overlain by twenty feet of yellow clay. The blue clay here contains an abundance of pebbles, many of them striated, pieces of coal, and iron nodules. Large boulders are rare.

Yellow Clay. The yellow clay rests upon the blue clay, and usually conceals it from view. In color it varies from buff to reddish yellow. It is arenaceous in places, sometimes grading into sand. These local sand areas within the more general clay formation often furnish supplies of water, as in the case of the blue clays below. Moreover this division evidently contains a much greater proportion of calcareous matter than does the blue clay. Pebbles are common, usually small and worn. Striated boulders are present, though less abundant than in the blue clays below.

The clay is cut irregularly by more or less vertical cracks which have become filled with lime by infiltration. In addition to this, the clay is more or less filled with concretionary

nodules of lime from one half to one inch in diameter. These resemble loess-kindchen. In some cases they are seen to be solid with a sand grain at the center. Often the calcareous concretions appear very abundant. No distinct evidences of stratification have been observed though such have been noted in this deposit in adjoining counties.

At numerous places the surface of the yellow clay is much oxidized and often has a well marked band of pebbles separating it from the loess above. When wet, the clay becomes soft and tenaceous, and in excavations gives much trouble from its tendency to creep. Usually the yellow clays vary from twenty-five to fifty feet in thickness.

The so-called "buffalo-licks" found in different parts of the county evidently represent localities in which these yellow clays contain a greater proportion than usual of calcareous matter and probably also a limited amount of salt, though no indications of this were detected.

LOESS.

The loess consists of fine ash-colored silt-like deposits resting upon the yellow clay. It rarely contains pebbles though occasionally small crystalline masses are observed. In well developed exposures, the lower portion consists of a dark, friable silt, while the upper part is much lighter colored and somewhat marly in appearance. West of Mount Zion a railroad cut shows the following arrangement:

		FEET.
5.	Soil	1½
4.	Loess, fine whitish silt	1½
3.	Loess, yellowish	4
2.	Loess, dark friable silt-like clay, containing loess-kindchen	4
1.	Clay, yellow with sheets and concretions of lime	30
		41

In thickness this formation does not exceed ten feet, the maximum being found on the uplands adjacent to the Des Moines river. It diminishes in thickness away from the river, and over the larger part of the county it constitutes only a thin veneer two or three feet in thickness. Much of it has been

removed by denudation along the Des Moines, the remainder forming a thin capping to the divides which still represent portions of the original plain level.

In well records the loess deposits are not differentiated from the yellow clays, and their absence in such sections therefore is not to be construed as an indication of non-development. The Holland well (Tp. 68 N., R. XI W., sec. 8, Sw. qr.), about two miles north of Milton gives the following arrangement:

		FEET.
4.	Clay, yellow	23
3.	Clay, dark blue, with some sand about sixty-five feet from top	181
2.	Rock, rather soft	1½
1.	Clay and sand with some gravel (water-bearing)	12
		217½

Water rose in the pipe 165 feet from the bottom. This well is located in the valley of Fox river, forty or fifty feet above the bottoms. A well on the Hargrave farm, one-fourth of a mile away and probably twenty-five feet below this, derives its supply of water from a sand bed under about twenty feet of yellow clay. This sand bed is evidently near the base of the yellow clay division. It is absent at Holland's, but apparently crops out near the level of the stream below. The Edmonson well, situated one-half mile north of Holland's, is 204 feet deep with a corresponding record. A well put down on the Manning farm (Tp. 68 N., R. X W., sec. 31, Nw. qr.), near Cantril shows:

		FEET.
3.	Clay, yellow	50
2.	Clay, blue, with boulders	60
1.	Sand and gravel with water	41
		151

Northeast of Bonaparte several wells have been drilled to rock, giving the following records.

CRESSWELL WELL SECTION.

(Tp. 69 N., R. VIII W., sec. 11, Sw. qr.)

		FEET.
3.	Clay, yellow	92
2.	Limestone, yellowish to white	6
1.	Limestone, white, in thin strata (water)	34
		132

This well is located on the prairie level and is noticeable in showing the absence of the blue clay. However, it is probable that a part of number 3 is referable to this division.

Nine miles northeast of Bonaparte is the Endersby well (Tp. 69 N., R. VIII W., sec. 12, Se. qr.).

		FEET.
3.	Clay, yellow	35 to 50
2.	Clay, blue, white below; contains gravel bed about thirty feet above the base	60 to 70
1.	Limestone, hard	1
		121

A well on the Percival farm one-half mile west of the preceding is 104 feet deep and shows a similar record.

ALLUVIAL DEPOSITS.

Alluvial deposits are well developed along all the larger streams and in the lower portions of the smaller tributaries. They occupy the comparatively wide bottom lands of Fox river and Indian creek, thinning out toward the top of the bluff on either side. Along the Des Moines, considerable areas are underlain by this formation, as at Farmington, Keosauqua and above Kilbourne. The extent of the deposits along the Des Moines, however, compared with the size of the stream, is much less than along Fox river. They are made up of dark colored silts, fine clays, sands and gravels. Along Fox river the clays and silts predominate.

The bottom lands are usually underlain by tough clays constituting an intractable soil prone to bake in dry, and drown in wet weather. These clay soils of the bottom lands are locally called "gumbo-soils."

Along the Des Moines river the most marked character of the deposits are the sand terraces marking the position of the river during various stages of its history. These are especially well developed in the Keosauqua "ox-bow." In this area eight well marked terraces have been determined, reaching up to an elevation of 145 feet above the level of the river. The remains of these terraces are in part represented upon the accompanying topographical map of the area.

HISTORY OF THE DES MOINES.

The present channel of the Des Moines river evidently dates from the glacial epoch. Where the river encounters the limestones of the Mississippian or Lower Carboniferous series, the channel is comparatively narrow with more or less precipitous rock escarpments.

West of Kilbourne, the soft coal measure rocks descend, passing below the river level near the west line of the county. Here the valley is wider and the slopes more gentle. In the vicinity of Farmington also, a similar condition prevails, though here in part attributable to depressions in the surface of the limestones. This valley therefore well illustrates the principal "that mature and old forms are more rapidly developed on soft than hard rocks." As a whole the valley shows the topographical characteristics of youth.

Figure 23. View at Keosauqua looking north from the bluff on the south side of the river.

At the middle of the county, the river forms a loop not unlike an ox-bow in shape. Between the upper points of the loop, the surface is very nearly on a level with the general plain to the northeast, of which plain it forms a part, (758 feet above

sea level). Along the line of the railroad, this has been reduced slightly by the backward erosion of the branches. It is evident that the Des Moines river flowed over this point, but was deflected southward somewhat at the very beginning. This course was probably determined by a slight depression below the general plain level, possibly due to irregularities in the rock surface or to glacial drainage. As erosion went on, its efforts were directed toward straightening its course by the corrasion of its left bank at the Kilbourne bend. The effect of this, however, was to cause still greater deflection southward which was increased when the hard limestones below were encountered. As the loop gradually extended itself southward, the stream encountered similar resisting rock walls, but of somewhat softer constitution, so that corrasion took place here more rapidly than before. For a time the corrasion was fairly uniform, giving the loop a regular outline. After reaching the ninety foot terrace level, however, the soft Keosauqua sandstone had been penetrated toward the east. By the descent of the strata to the southwest this sandstone remained about at the river level, so that while corrasion was taking place quite rapidly in the soft sandstone toward the southwest the hard limestone eastward offered a much more effectual resistance, giving rise to the northward bend below Keosauqua, instead of a uniform curve which would result if the rocks were of uniform hardness.

Terraces. The highest terrace is about 140 feet above low water at Keosauqua. From this point the terraces descend quite uniformly. The most marked are the following:

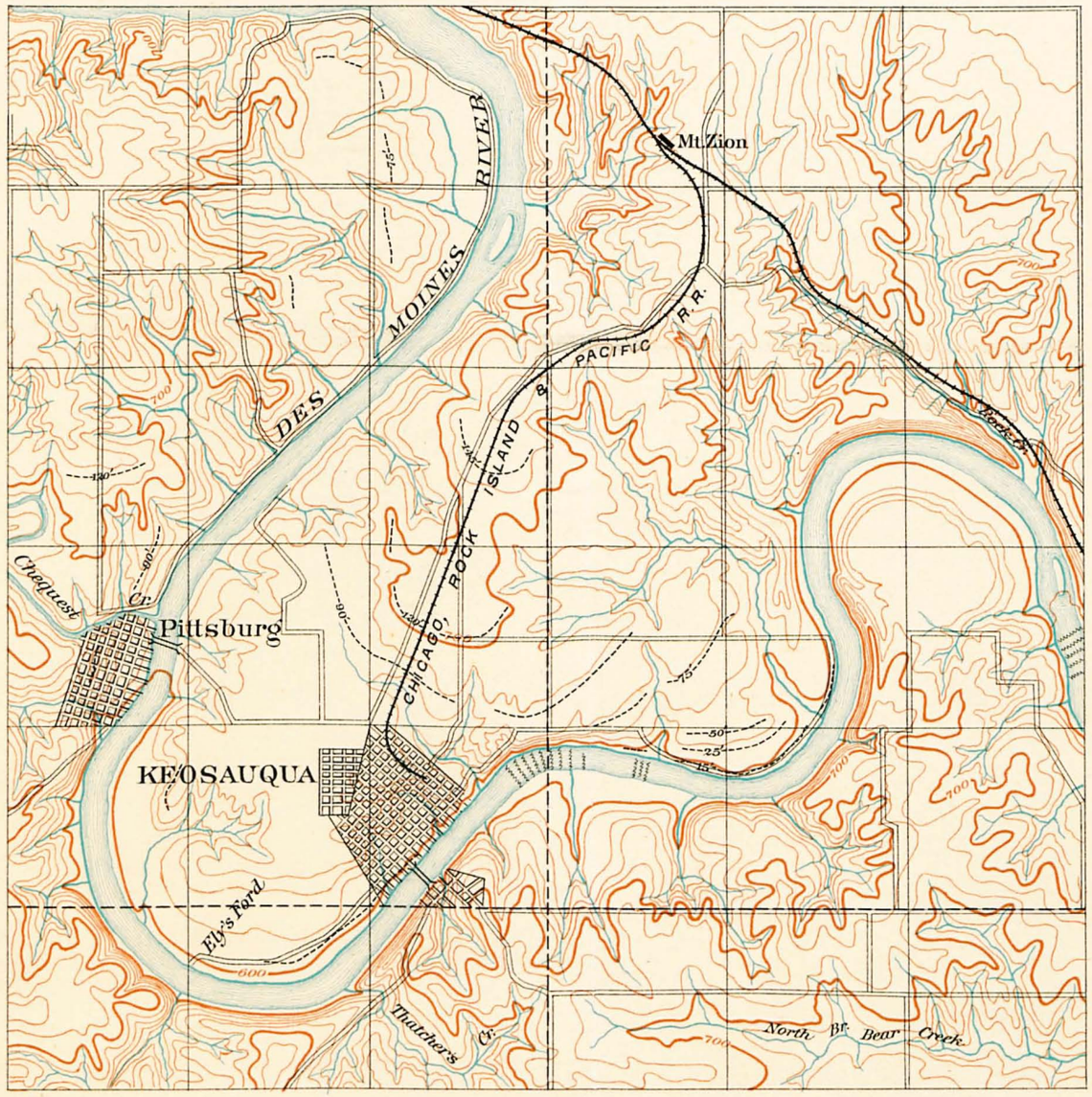
145 feet	120 feet	90 feet
75 feet	50 feet	25 feet
15 feet	and	10 feet

These terraces are marked upon the accompanying topographic map of the Keosauqua region. (Plate vii.)

Geological Structure.

DEFORMATIONS.

Bentonsport Anticlinal. In general, the strata have a southerly slope of about four or five feet to the mile. Corrugations



A

TOPOGRAPHIC MAP

OF THE

KEOSAUQUA OXBOW

BY

CHARLES H. GORDON.

LEGEND

HIGHWAYS ═══

TERRACES - - - - - -

SCALE: 1 INCH = 1 MILE.

CONTOUR INTERVAL 20 FEET.

A. Hoen & Co. Lith. Baltimore.

of a minor character, however, interrupt the general inclination. The most pronounced of these beds is the Bentonsport arch and anticlinal, having its crest at the place from which it takes its name. Its strike is about N. 63° W., pitching quite abruptly toward the west but gradually toward the east, reaching the Mississippi near Nauvoo at which point it is scarcely perceptible, (figure 1, plate vi.)

At Bentonsport forty feet of the Burlington cherts are exposed above the river, indicating a rise of nearly 140 feet from Farmington to this place. A descent toward the north appears to pass into a trough-like depression between Mount Zion and Birmingham. This is illustrated in the accompanying profile section from Birmingham to Cantril (figure 2, plate vi). The uplift giving rise to the Bentonsport arch evidently occurred before the deposition of the coal measures. This is indicated by the way these deposits lie against it on the north, as shown by the arenaceous character and relations of the beds north of Mount Zion. Moreover the character of the Saint Louis formation in this vicinity favors the belief that the Bentonsport area was at or above sea level during a part of the epoch at least, but there is no evidence to show that such was the case during Keokuk times. The flexure may have had its origin therefore in the oscillations known to have occurred in this region during the early part of the Saint Louis.

UNCONFORMITIES.

UNCONFORMITY BELOW THE SAINT LOUIS.

It has usually been considered that in this region the Saint Louis rests conformably upon the Keokuk beds. Farther north, however, they are known to be uncomformable. At several places in Van Buren county a disturbance of the sedimentation, which may be indicative of unconformity, appears at the juncture of the two formations. This is well shown on Rock creek, near Kilbourne and elsewhere. At this horizon there occurs a confused mingling of calcareous and arenaceous materials, including broken fragments of chert and shells and decomposed limestone. While not decisive, the phenomena suggests that during the time these deposits were forming they were near enough

to the sea margin to be subject to shore influences. This evidence of unconformability is further strengthened by the marked thinning of the Warsaw formation northward. It is probable therefore, that the Iowa-Missouri line appromimately marks the point to which the sea retreated at the close of the Keokuk age; and from which it again advanced northward during the age succeeding.

UNCONFORMITY BETWEEN THE SAINT LOUIS AND DES MOINES FORMATIONS.

The interval between the Saint Louis and the Des Moines or lower coal measure rocks, represented farther southward by the Kaskaskia, is here marked by extensive evidence of prolonged erosion. Exposures showing the discordant relations of these deposits are seen at many places. The following figure illustrates an exposure on Bear creek (Tp. 68 N., R. IX W., sec 10, Sw. qr).

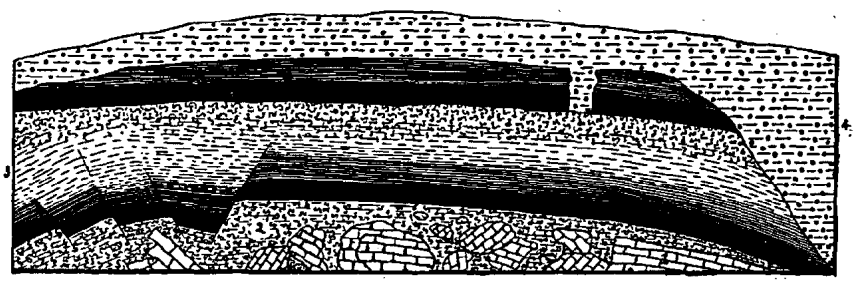


Figure 24. Exposure of coal measures on Bear creek.

In the figure the coal measures are shown resting on the decomposed surface of the Saint Louis limestone. Number 1 is a white granular limestone; 2, residuary clay including more or less decomposed fragments of 1; 3, shales and fire clay including two thin seams of coal, and, 4, surface clay.

The lower coal is here underlain by residuary clay containing fragments of limestone, siliceous rock and chert derived from the underlying limestone. The limestone fragments are much decomposed and coated with iron oxide. They represent the upper white limestone of the Saint Louis. About one hundred yards below this locality the coal measure rocks rest upon the worn surface of the brown magnesian limestone. The following represents an exposure on Coates creek (Tp. 69 N., R. VIII

W., sec. 20, Se. qr.), the coal measure sediments resting in channels cut in the surface of the Saint Louis beds.

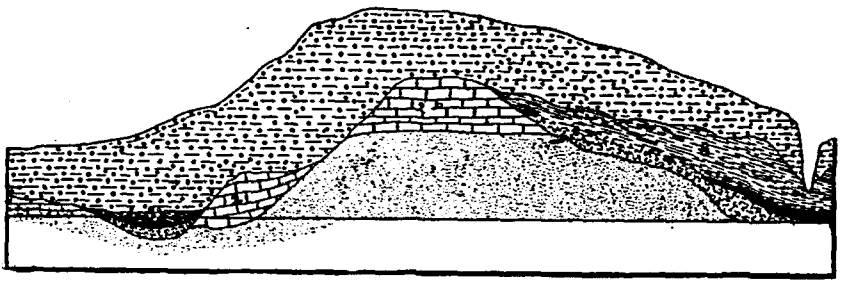


Figure 25. Diagrammatic section on Rock creek (west branch. Tp. 69 N., R. IX W., sec. 24, Nw. qr.), showing erosion unconformity between the Saint Louis and Des Moines formations.

In this figure number 1 is the Keosauqua sandstone; 2, a compact limestone; 3, the coal measure shales and clays with small bits of coal, and, 4, surface clays. Vertical scale much exaggerated.

On Rock creek coal measure shales are seen resting upon the magnesian limestone at the base of the Saint Louis, while the higher members of the same number are well exposed in the bluff a short distance below.

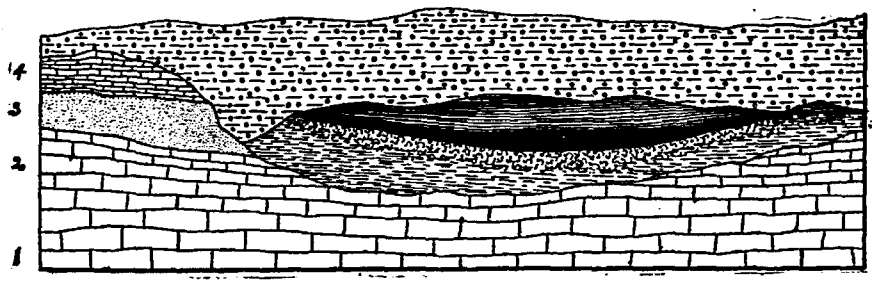


Figure 26. Unconformity below the coal measures on Coates creek.

In figure 26 number 1 represents magnesian limestone (arenaceo-magnesian beds); 2, brecciated limestone; 3, Keosauqua sandstone; 4, compact limestone; 5, bituminous shales; 6, surface deposits.

ECONOMIC PRODUCTS.

COAL.

In the vicinity of Farmington, coal has been mined more or less for many years. On the south side of the river, it was at

one time mined at Boyer's station, but the workings are now abandoned. It is still mined somewhat for local use in the Tp. 67 N., R. VIII W., sec. 3, Se. qr. The most productive areas, however, are on the north side of the river.

North of the river the coal occurs in basins in the limestone. Frequently, at the middle of the basin, the coal is found to rest upon several feet of sandstone and fire clay while towards the edges the sandstone and fire clay thin out, allowing the coal to rest directly upon the limestone. The section from this vicinity appears on page 209. The field, as now known, comprises four separate basins of workable coal nearly all of which has been exhausted. One of these covered ten acres, two about fifteen acres each and one twenty-five acres.

The thickness of the coal varies from four to six feet. The only mine now being operated is located in Tp. 68 N., R. VIII W., sec. 26, Se. qr. It is situated on the hillside about a quarter of a mile north of the railroad track. The top of the shaft, which is fifty feet deep, is about seventy-five feet above the track. The coal is said to vary from four to six feet in thickness.

Coal is mined to some extent for local use at several places along Coates creek. It is here evidently in basins similar to the deposits at Farmington. Mining has also been carried on to some extent on the south side of the river at Keosauqua, as also at Pittsburg. The seams are thin, however, and of rather poor quality.

The only mine along the river between Farmington and Doud's now being worked, is that of Jacob Boyer's on Bear creek, (Tp. 68 N., R. IX W., sec. 3, S. ½). The section here is as follows:

		FEET.	INCHES.
6.	Concealed		
5.	Coal		6
4.	Whitish sand rock, very hard, called "clod" sometimes changes to black shale....6 to	12	
3.	Coal	3	
2.	Fire clay		3 to 4
1.	Sandstone	?	

The rock above the coal is strongly charged with sulphur, and water percolating through it becomes impregnated with acid.

The center of the coal mining industry in Van Buren county is at Douds. Here the coal occurs at a higher horizon than towards the east, a considerable thickness of clay shales separating the coal from the limestone below. Four mines are being operated here, all of which are evidently located in the same basin. The coal is of fairly good quality, though more or less impregnated with sulphur, sometimes in the form of iron pyrites.

Carson's mine is located in Tp. 70 N., R. XI W., sec. 24, Nw. qr. At this mine the coal is obtained by drifting and has been worked more or less for thirty years. The coal averages from three and one-half to three and three-fourths feet in thickness. About thirty acres have been exhausted.

Hugh Findley's mine (Tp. 70 N., R. XI W., sec. 24, Ne. qr.), is situated but a short distance east of Carson's on the opposite side of the branch and was opened in 1892. The estimated area exhausted is about three-fourths of an acre.

Ratcliff's mine (Tp. 70 N., R. XI W., sec. 23, Nw. qr.) was opened in 1892. The section of this mine was given on page 226.

G. W. Findley's mine (Tp. 70 N., R. XI W., sec. 14, Se. qr.) is situated in a small valley, and the coal is reached by a shaft. The approximate area from which coal has been exhausted is about five acres.

A. Hinkle's mine is situated about two miles east of Selma, or Independent (Tp. 70 N., R. XI W., sec. 10, Sw. qr.). The coal occurs but little below the level of the valley, and the thin covering of shale affords a poor roof. About ten acres have been exhausted on the east side of the creek and a new opening on the west side has proven troublesome from the falling of the roof. The air shaft shows the following section:

		FEET.	INCHES.
5.	Alluvial clay or sand	10	
4.	Shale, bituminous with lenticular masses of black limestone	4	
3.	Coal	3	3
2.	Iron pyrites		3 to 6
1.	Fire clay		

No coal is now mined here, though efforts are being made to put the mine in working order. The coal occurs at about the same horizon as at Douds, a nd probably belongs to the same basin.

La Fever's mine is situated on the south side of the river (Tp. 70 N., R. XI W., sec. 17, Sw. qr.). The section is as follows:

		FEET.
6.	Concealed	?
5.	Coal	1½
4.	Fire clay	3
3.	Shale, bituminous	9
2.	Coal	3 to 3½
1.	Fire clay	

An older drift near by has been worked intermittently for about twenty years. Coal has been taken out also on the farm of Mr. Beitti in the southeast quarter of section twenty (Tp. 70 N., R. XI W.). The supply was limited, however, and is now exhausted. The bed is said to have been abruptly terminated by yellow clay evidently indicating a preglacial, drift-filled channel.

At the Overturff's coal bank the upper bed of coal (p 226), evidently belongs to a higher horizon than the preceding. Very little effort has been made to mine this coal and its extent is unknown. About one-half acre has been exhausted. No mining is being done here at the present time. Some coal has been taken out on section five and six in the Lick creek township, which may represent the Overturff seam. A seam two feet thick on the farm of John Beal is mined somewhat for local use.

Mathias coal bank is located in Tp. 70 N., R. X W., sec. 17, Ne. qr., and has yielded a limited amount of coal for several years. A new opening now being made on the hillside furnished the following section:

		FEET.	INCHES.
8.	Clay, red	33	
7.	Sand	4	
6.	Coal		7
4.	Limestone, brown	2	9
5.	Limestone, blue	1	3

		FEET.
3.	Shales, black, somewhat massive; with limestone "boulders"	2
2.	Coal	3
1.	Fire clay	15+

The so called fire clay here is probably in part shale. This may be correlated with the Doud's coal. About an acre has been worked out here. This same seam has also been worked about half a mile farther east, on the farm of T. G. Moyer, but the opening has been abandoned for several years.

Fuller's coal bank is an opening made by F. B. Smith, of Birmingham, in a seam cropping out on the land of Charles Fuller. (Tp. 70 N., R. X, sec. 26, Ne. qr.) The section is as follows:

		FEET.	INCHES.
6.	Concealed	?	
5.	Shale, bituminous and sandy	8	
4.	Sandstone, somewhat ferruginous with coaly seams	4	
3.	Shale, bituminous		5
2.	Coal	2	8
1.	Sandstone, blue	4	

Very little coal has been taken out here as yet, and no inference can be made as to the extent of the bed, or its relation to other basins. East of this, on the east branch of Brick creek there occurs a coal seam which apparently represents the same horizon.

Taylor's local bank is in the northeastern part of the county. Coal has been mined here (Tp. 70 N., R. VIII W., sec. 14, Nw. qr.) for thirty-five years. An exposure shows the following arrangement:

		FEET.	INCHES.
8.	Concealed	15 to 25	
7.	Shales, black, fissile	1	6
6.	Sandstone, ash gray, irregularly indurated	1	
5.	Coal, includes lenticular layers of sandstone	2	
4.	Shale, black, fissile, calcareous		10
3.	Fire clay	3	
2.	Concealed	5	
1.	Limestone, in bed of creek (Saint Louis)		

In an old opening near by, the coal occurs in two benches aggregating over six feet.

		FEET.
4.	Shale, black, forming a good roof	4
3.	Coal	4
2.	Shale, black, coaly	1
1.	Coal	2½

This, however, is a local development, as adjacent openings do not show more than three feet. The amount of coal mined here is limited to the local demand, and the area exhausted probably does not exceed an acre. No reliable estimate can be made of the extent of the basin, though it is probably limited. This locality was visited by Worthen in 1856*.

The Yargus coal bank is situated about a mile southeast of Taylor's bank (Se. qr. sec. 23). The coal is about three feet thick and rests upon the Saint Louis limestone with three or four feet of fire clay between. About two acres have been exhausted. The coal is mined intermittently for local use only. The rise of the limestone in the creek bed toward the west suggests that this coal lies in a basin which may or may not be connected with that of Taylor's bank. Toward the east, coal, probably belonging to this same basin, is mined to some extent, near the county line at Cox's bank and elsewhere.

CLAYS.

CHARACTER AND DISTRIBUTION.

The clay industry of Van Buren county has not reached so important a development as in the neighboring counties. This has been the result of the relative abundance of good quarry stone rather than the absence of suitable material for the manufacture of building brick.

The county affords four series of clays which are to a greater or less extent available. These are coal measure, drift, loess and alluvial clays. The Mississippian series as exposed in this county rarely yields any clay available for manufacturing purposes.

*Geology of Iowa, vol. 1, p. 151. Albany, 1858.

The coal measures are widely distributed throughout the county. They are very largely composed of shales of various kinds. The bituminous shale so commonly found in connection with coal seams is of small value. The grey, blue and drab shales may, however, usually be found and are almost always of excellent quality for the manufacture of pavers, as well as for building brick, and the finer grades of face brick. Fire clay is here, as usual, found in connection with the coal seams. It may be used for brick, refractory material or pottery. There are at present two potteries in the county which obtain their material from this source.

The drift clays are as usual full of disseminated gravel which lessens their value. Both the blue and yellow clay is, however, at certain points of sufficient purity to be available.

The loess of this county occurs as a thin sheet spreading over the uplands. While it is not so thick here as in many other counties of the state, it presents the same characteristics which have caused it to be so widely used. Its very general distribution and the fact that it is so easily treated, and is adapted to so wide a variety of uses, makes it especially valuable.

The alluvial material developed along the Des Moines and Fox rivers, and to a less extent along the smaller streams has already been used to a certain extent. It is an abundant source of material for the commoner and cheaper forms of building brick. It is especially adapted to the manufacture of hand brick, and could be used here much more widely than has thus far been attempted.

CLAY INDUSTRIES.

KEOSAUQUA.

Charles Schreckengost in 1893 began the manufacture of brick from a drift clay. The material is crushed and mixed in a horse power mud mill and moulded by hand. The bricks are burned in open kilns. They are of fair quality though rather porous. The trade is local. H. A. Whitmore also manufactures a hand brick from surface soil taken to a depth of about eighteen inches. The bricks are burned in open kilns and used locally. A few have been shipped to other points in the county, the

Farmer's Savings Bank at Farmington being built of this brick made at this yard.

VERNON.

The Vernon pottery is located on a hill south of town. It is operated by Mr. R. M. Dickson and has been running for fifty-two years. In addition to jugs, jars, milk crocks and other forms of pottery, small quantities of sewer pipe and of fire brick are made. The clay is obtained from the coal measures about three miles from the pottery. It is of good quality and works up nicely. A total of about 140,000 gallons represents a years output. The wares are shipped throughout this and neighboring counties and find a ready sale. About thirteen skilled workmen are employed.

BONAPARTE.

H. A. Whitmore burns brick at Bonaparte. Soil is used being taken to a depth of eighteen inches. The bricks are hand moulded and burned in cased kilns. The trade is local.

FARMINGTON.

J. F. Leavitt began in 1894 the manufacture of brick at Farmington. Alluvial clay is used. The material is mixed in a horse power pug mill and the common or stock bricks are moulded by hand. The face brick is repressed on a hand power perfection press and the ware is burned in cased kilns. A good product is being turned out.

W. Wen. In east Farmington just north of the Chicago, Burlington & Kansas City railroad bridge is a pottery opened in 1894. The material is obtained from the shales of the coal measures and is crushed on a horse power, Akron, Ohio, machine. The ware is burned in one up draught kiln having a capacity of 1,500 gallons. Flower pots and drain tile have so far been made. The latter is made on a hand power machine of English make.

CANTRIL.

The Cantril Brick Company has been in operation since 1891. They use a surface clay, mixed in a horse power pug mill, moulded by hand and burned in up draught kilns. The clay shrinks considerably in drying and burning, but forms a

tough, hard hand brick of good color. Haney Brothers also manufacture brick from a similar clay by the hand process.

MILTON.

Sylvester Fogelsong began at Milton in 1893 the manufacture of brick from surface clay by hand process. Homer Powers also makes brick here from a similar clay, having burned his first kiln in 1894.

BUILDING STONES.

Limestone and sandstone for ordinary masonry occur in inexhaustable quantities all along the Des Moines river.

LIMESTONES.

Limestone suitable for heavy masonry is abundant in the arenaceo-magnesian beds of the Saint Louis, while the Keokuk beds at Bentonsport have supplied large amounts. The concretionary character of the magnesian beds, however, interferes with the working of the stone, and unfits it for use where dressing is required. The beds are usually thick, and present considerable difficulty in quarrying except where worked on a large scale. These beds were quarried quite extensively at many places along the Des Moines for the construction of dams in the days of river improvements, for which purpose the rock was well adapted. The white limestones are drawn upon more generally for ordinary building purposes. The hardness of the rock, however, precludes its use where a dressed stone is required.

DOUDS.

About two miles east of Douds (Tp. 70 N., R. X W., sec. 31, Nw. qr.), the Saint Louis limestone was in 1894 opened up for quarrying. The stone, however, proved to be of inferior quality and only a small amount was taken out.

KEOSAUQUA.

The white limestone is quarried at several localities near Keosauqua. On Thatcher's creek, one and a half miles south (Tp. 68 N., R. X W., sec. 2, Sw. qr., Se. ¼), Mr. Manning has taken out stone at several points on both sides of the creek.

Stone has also been taken out on east Thatcher creek (Tp. 68 N., R. X W., sec. 1, Se. qr.). The stone at all three quarries is of the same lithological character. East of town on the north side of the river (Tp. 69 N., R. IX W., sec. 31, Sw. qr.), is the S. D. Fellow quarry, also in the Saint Louis. This quarry has been operated for the local trade some twenty-five years. The ledges are twelve to fifteen inches thick and suitable for foundation and rough building purposes.

ROCK CREEK.

Stone has been taken out along Rock creek at two or three points (Tp. 69 N., R. IX W., sec. 21, Nw. qr., Ne. ¼). The rock belongs to the Saint Louis and so far has only proven suitable for local foundation work.

BENTONSPORT.

The Keokuk limestone was extensively quarried at Bentonsport about eight years ago for bridge building and riprap. In the winter of 1893-4 about 1,000 cubic yards were taken out and used to protect the piers of the bridge which were then decaying. Since then no stone has been quarried. Only the upper ledges are used. Three-quarters of a mile east of Bentonsport (Tp. 68 N., R, IX W., sec. 1, Se. qr., Ne. ¼) the Chicago, Rock Island & Pacific railroad has taken out a small amount of stone from equivalent layers. The quality is poor and none is now used.

BONAPARTE.

Directly across from Bonaparte (Tp. 68 N., R. VIII W., sec. 17, Nw. qr., Nw. ¼) a small amount of stone was quarried some years ago, but the quarry was never extensively developed. The main quarries are on the north side of the river and have been worked for twenty-five years or more. The quarries are on Reed's creek and supply a good stone which dresses well. It has been used for the engine room of Meek Brothers woolen mill and the piers of the Bonaparte bridge. It is also used extensively for local work furnishing foundation stones, window sills and caps, and well and cellar rock. The stone comes from the arenaceo-magnesian division of the Saint Louis.

A short distance east of town the Keokuk limestone is occasionally quarried for local purposes. A section here (Tp. 68 N., R. VIII W., sec. 9, Se. qr., Sw. ¼) showed the following layers:

		FEET.
3.	Drift	3
2.	Limestone, blue, irregular, thin bedded; intermixed with layers of shale; fossiliferous, cherty	7½
1.	Limestone, blue, hard, cherty, thick bedded; main quarry rock; exposed	6
		16½

The stone is very hard to work. Farther up the creek the fine grained yellow limestone occurs but has not been developed. Still farther east (Tp. 68 N., R. VIII W., sec. 15, Ne. qr.) Meek Brothers formerly quarried a small amount of rock.

FARMINGTON.

The south-western drift-covered portions of the county is largely supplied with rock from the Indian creek quarries near Boyer (Tp. 67 N., R. VIII W., sec. 5, Ne. qr., Nw. ¼). A section seen here showed:

		FEET.	INCHES.
4.	Drift	3	
3.	Limestone, shaly with interbedded clay seams		6
2.	Limestone, grey, coarse sub-crystalline	2	6
1.	Limestone, fine grained, smooth, with conchoidal fracture; pure above, coarser and more impure at base	5	10

Stone has been quarried here for many years for building and rip-rap. The stone is too hard to dress nicely and is used mainly for rough masonry, caps and sills.

Chequest Marble. On Chequest creek a ledge of the Saint Louis limestone near the middle of the formation has been utilized to some extent for tombstones, and is known as Chequest marble. It consists of a compact, dove-colored limestone and is susceptible of a good degree of polish. It was from this bed that a block was sent by the citizens of the county for use in the Washington monument.

SANDSTONES.

On Bear creek south of Bentonsport (Tp. 68 N., R. IX W., sec. 11, Nw. qr.), the blue sandstone of the arenaceo-magnesian beds has been quarried for many years. While the rock is sometimes of poor quality, excellent stone for window sills and like uses is obtained from this locality. A good development of these "sandstones" occurs also at Price's, now Rockdale quarry, three miles west of Pittsburg. The stone appears to be of good quality. Some of the foundation stone for the bridge at Pittsburg was obtained here. The section in the quarry (Tp. 69 N., R. X W., sec. 20, Sw. qr.), showed the following:

		FEET.
3.	Drift	4
2.	Limestone, fine grained, arenaceous, compact; weathering yellow	10
1.	Limestone, light colored, arenaceous, fine grained hard; exposed	3½

The stone is now used only for rough masonry. The brecciated beds and the white limestones sometimes furnish ledges that may be utilized for the manufacture of lime. Kilns were formerly in operation on Indian creek, near Keosauqua, at Bonaparte and several other points.

SOILS.

The soils of the county may be classified as loess and drift soils, and alluvial soils. Of these the former covers by far the greater portion of the county. The thin mantle of loess covering the divides both north and south, constitutes the best soil of the region, where the drainage is sufficient to remove the excess of surface waters. The broad level plateaus in the northeastern part of the county have proven intractable in places owing to insufficient drainage. By the adoption of better methods in farming, these areas are being brought under cultivation and will eventually prove as valuable as any of the lands in the county.

Along the slopes where surface erosion has removed the mantle of loess, the soil is in large part derived from the underlying yellow drift clays, with a portion of the loess which has

crept down the hillsides. In these cases the inferior character of the soil is in part compensated by improved drainage. These slopes are therefore usually well wooded, but are not well adapted for tilling. Where the drift clays contain a considerable proportion of sand they are much improved as a soil, owing to their greater porosity. In some cases over the plateau, the loess is so reduced in thickness that the yellow clays practically lie at the surface. In this case the fertility of the soil is largely dependent upon the proportion of sand which it contains. The buffalo licks are such areas of limited extent in which clay predominates to such a degree as to make the soil scarcely tillable.

The alluvial soils are well developed along the Des Moines and Fox rivers, and to a lesser extent along the larger of their tributaries. The bottom lands of the Fox are in large part unavailable for cultivation on account of being subject to overflow. In places also they are underlain by a dense tenacious clay soil termed "gumbo," which is almost wholly intractable. If the drainage of these areas could be controlled, they would doubtless prove valuable for tillage. As it is they are largely devoted to grazing, and by careful attention they may be available for hay. Along the Des Moines valley, the soils are characterized by a much greater proportion of sand than elsewhere. The flat areas, as at Keosauqua, represent the location of the overflow swamps at the time the terraces were forming along their border. These were originally wet and swampy, but now furnish a fairly good soil, though less valuable than that of the upland plateau.

ROAD MATERIALS.

Abundant material for the improvement of roads occurs along the Des Moines and its tributaries. The limestone beds furnish inexhaustable supplies of material for macadamized roads, while sand may be had in abundance along all of the larger streams of the region. A short distance east of Farmington there is a gravel pit which has furnished considerable ballast for the Chicago, Burlington & Kansas City railway. The greatest depth worked is eighteen feet. Of this, eight feet near

the top of the section is of coarse gravel. The remainder is a coarse, beautifully cross-bedded sand containing pebbles. Directly south of here is a second pit twelve feet deep which belongs to the Chicago, Rock Island & Pacific railway. It was opened in 1879 and has furnished ballast for about twenty-five miles of track.

MINERALS.

Pyrite. Iron pyrites is sometimes abundant in the coal and shales of the coal measures and to a less extent occurs also in the limestones and shales below. It occurs in the former usually in concretionary masses of yellow metal with crystal forms. Good crystals are sometimes found in cavities in the black limestones occurring above the Douds coal. In the limestones and shales of the Lower Carboniferous rocks, pyrites sometimes occurs in small crystals and lumps, but is more commonly disseminated in grains through the rock.

Calcite. Beautiful crystals of calcite frequently line the interior of the hollow spherical concretions termed geodes which characterize the geode shales of the Keokuk formation. These geodes are usually abundant along the lower courses of the streams intersecting these shales, in the vicinity of Bentonsport and Bonaparte. Dog tooth spar is also sometimes found lining small cavities in the shales above the Douds coal. Calcite also occurs associated with the filling of irregular cracks in these limestones.

Sphalerite is occasionally found in geodes. This mineral is also found in the drift.

Selenite. The black limestone over the Douds coal seam contains small amounts of selenite in thin tabular crystals.

WATER SUPPLIES.

For water the chief dependence is placed upon the shallow wells confined to the drift deposits. Along the Des Moines, the river constitutes an unfailing source of supply for general and stock purposes, but at a distance from the stream considerable difficulty is often experienced, as the wells cannot be relied upon for a very large supply during the summer months. In a few cases drilling has been carried down into the Lower

Carboniferous rocks, as at the Edmonson, Davis, Miller and other wells. In only one of these, however (Miller's), has a satisfactory supply of water been obtained. The only flowing wells in the county are along the Des Moines; one at Farmington, and one at Bonaparte. These holes were put down in search for oil or gas, and failing they were abandoned. There has been no attempt made to use the water supply, and no record of these wells is now available.

At Keokuk, several flowing wells occur, ranging in depth from 740 to 1800 feet. The first flow comes from a sandstone presumably belonging to the Niagara series, at about 737 feet from the top of the bluff, or about 100 feet below sea level. Additional flows are obtained at intervals from 1200 to 1800 feet. The water from the lower beds shows a less proportion of iron and other mineral ingredients than that from the higher strata. As Van Buren county does not differ essentially from Lee county in its geological structure, it is quite probable that adundant supplies of water may be obtained anywhere in the county at from 700 to 900 feet, according to the location of the well. The water at this horizon is quite highly charged with mineral, however, and may not always prove wholly acceptable for general use.

The height to which the water will rise has not been tested at Keokuk but it flows with strong force at an elevation of 638 feet. At Mount Clara which has an elevation of 679 feet, the water in W. J. R. Beck's well, which is 939 feet deep, rises to within six feet of the surface corresponding to an elevation of 673 feet. If there is no escape of water above the rock surface here, this altitude may be considered to represent the level to which water from the same horizon (Niagara) will rise throughout the region. As to the lower water-bearing beds, nothing is known in this regard, though they may possibly have a higher head. In testing for flowing wells, therefore, the elevation of the locality must be taken into consideration. From the table of elevations on page 202 it is seen that the plateau level varies from 750 to 800 feet, and hence flowing wells cannot be looked for here from the Niagara horizon, unless they start in depressions from eighty-five to one hundred and fifty feet below the

general plateau level. Evidently no difficulty should be encountered in obtaining flowing wells within the Des Moines valley. Whether the lower beds will give flowing wells on the uplands remains to be tested.

ACKNOWLEDGMENTS.

The author tenders his hearty thanks to all who have assisted in the prosecution of the work involved in the preparation of this report. Special acknowledgments are due to Judge Robert Sloan, W. A. Duckworth, S. E. Irish, B. Johnson, W. R. Carson, Hugh Findley, M. Stoddard, R. G. Merrill, and others who have kindly furnished information and rendered assistance in many ways. Also to Dr. T. C. Chamberlin and Mr. F. Leverett, to whom the author is indebted for many helpful suggestions, as well as to Mr. E. H. Lonsdale for notes on the clays and clay industries, and to Mr. A. J. Jones for supplementary notes on the building stones.

IOWA GEOLOGICAL SURVEY

GEOLOGICAL MAP OF VAN BUREN COUNTY, IOWA.

BY

CHARLES H. GORDON.

1895.

B — C — A

R. XI W. — R. X W. — R. IX W. — R. VIII W.

T. 70 N. — T. 69 N. — T. 68 N. — T. 67 N.

VILLAGE — LICK CREEK — UNION — CEDAR

CHEQUEST — VAN BUREN — WASHINGTON — HARRISBURG

DES MOINES — HENRY — BONAPARTE

JACKSON — VERNON — FARMINGTON

Independent — Business Corners — Winchester — Longview — Stockport — Mac Veigh — Utica — Birmingham — Pittsburg — Keosauqua — Pleasant Hill — Mount Zion — Pierceville — Rentonsport — Vernon — Lebanon — Oak Point — Milton — Home — Cantril — Niles — Mount Sterling — Willet — Farmington — Upton

Des Moines River — Chequest Creek — Lick Creek — Little Cedar Creek — Cedar Creek — Bear Creek — Indian Creek — Little Fox River — Fox River

Chicago, Rock Island & Pacific Railroad — Des Moines River & Fort Madison Railroad — Keokuk & Des Moines Railroad — Chicago, Burlington & Quincy Railroad — Kansas City Railroad

LEGEND

GEOLOGICAL FORMATIONS.

- DES MOINES (Coal Measures)
- SAINT LOUIS
- AUGUSTA

INDUSTRIES.

- QUARRIES
- COAL MINES
- CLAY WORKS
- LIME KILNS
- BORINGS

DRAWN BY F. C. TATE.

Photo-Lith. by A. HOEN & CO., Balto., Md.